Regulating Sedimentation and Erosion Control into Streams: What Really Works and Why

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Abstract

The overall objective of this project was to determine the effectiveness of different environmental policies, regulations, and incentives in reducing the ecological risks and consequences of sedimentation to streams. We were trying to learn which sets of regulations, enforcement strategies, and landscapes result in effective protection of stream communities from degradation, resulting from erosion and sedimentation from construction sites. By connecting erosion control efforts to environmental impacts, our aim was to create more effective management strategies that ultimately provide environmentally sustainable social and economic development in our watersheds.

We chose four replicate construction sites in each of three regulatory jurisdictions that varied in stringency of regulations and enforcement activities. At each site, we conducted instream assessments of water quality and biomonitoring of macroinvettebrates and fishes to determine the success of the regulators in protecting stream ecosystem health. We combined these results with evaluations of the regulatory environment to link the policies and management styles of the regulators to the effectiveness of protection of the streams. While all construction sites did some damage to the steams, we found that enforcement style and frequency of inspections were far more important than the nature of the regulations in preventing sediment pollution of streams.

Keywords: Development, enforcement, rivers, sedimentation, streams, regulations, regulatory effectiveness.

Introduction

A critical problem in American rivers and streams is sedimentation. Sedimentation degrades water quality, alters habitat for fish and macroinvettebrates, limits ecosystem functions and services, and reduces the aesthetic and economic value of rivers and streams. Many regulations and policy incentives have been devised to control sediment pollution of our rivers and streams. Yet there has rarely been an attempt to reconnect the policies with the ecology of the rivers. That was the goal of this research. This work integrates the regulatory environment, sediment ordinances, and policies with resultant ecological impacts of sedimentation on rivers and streams. The question the ressearch sought to answer was "What combinations of policies, regulations and on-site interactions between regulators and developers really work to enhance stream biota and stream ecosystem health?"

Research goals were accomplished by comparing similar streams in different regulatory jurisdictions (a comparative watershed approach). We tested the effectiveness of different intensities of sediment control regulations and enforcement. We used the streams to tell us what matters ecologically. The selected political jurisdictions differed in the stringency of their erosion and sediment control requirements and the nature and intensity of enforcement of the regulations. We chose 17 construction sites along streams in three different jurisdictions. We interviewed the regulators

and developers at each site and we studied the regulations and the attitudes of the regulators and developers. At each site, we sampled the streams being impacted. Some projects are still unfinished. Therefore, we will present only the results of the 'before construction' and 'during construction' samplings.

We asked "Which erosion and sediment control regulations really work and why?" We have analyzed the erosion and sedimentation control regulations and compared them among the respective jurisdictions. Then we surveyed the attitudes and enforcement activities at all levels within each jurisdiction. This paper will briefly outline our findings and focus on what can be done to minimize sedimentation into streams from construction sites.

Methods

Site Selection

We selected three regulatory jurisdictions so they would vary across a range of two critical variables: (1) stringency of regulations (how strict and how rigorous the rules are) and (2) stringency of enforcement (i.e. frequency of inspections, severity of punishment of violations). A summary of some of the salient characteristics of the three regulatory jurisdictions is given in Table 1. Construction sites were selected from the array of applications for grading permits filed with the erosion and sediment control offices in each jurisdiction. The biggest constraint in locating study sites was the availability of construction sites on streams with riffle zones, One jurisdiction (District IV) extends eastward into the coastal plain as does Eastern Wake County. Therefore, many otherwise promising sites, which had sandy bottomed, slow flowing streams, were eliminated from our study. To be selected for this study, the construction sites had to have certain critical characteristics. For example, streams had to be within 100m of the site. There also had be a significant slope from the construction site down to the stream, so that if erosion occurred it would impact the stream. These factors made site selection extremely difficult. In this paper, we will discuss only the impact of large construction sites (>100 acres disturbed). We have located and sampled ten large sites.

Table 1. Selected Characteristics of Erosion and Sediment Control Jurisdictions Used for this Project

	Minimum Disturbed Area Requiring Erosion Plan Staff	# Field (Miles')	Total Area Projects	# Active	Site/Staff Ratio
Orange County	0.5 Acres	3	400	-100	33.3
Wake County	1 .O Acres	4	858	-400	100
District 4' (16 Counties)	1 .0 Acres	4	8,116	-1000	250

* District 4, of the NC Division of Land Quality oversees all construction projects in all 16 counties without a Local Erosion and Sediment Control Program. It covers all governmental construction in the District 4 area, including Orange and Wake Counties. So, a single stream can have adjacent construction sites along the banks, one supervised by District 4 and the other by the Local Program.

Stream Sampling Procedures and Variables Sampled

We monitored at least three replicate sites per jurisdiction for the large construction sites. We sampled before, during, and after construction. We cannot control the timing of the construction projects, and since sampling must follow a rain of >1/2" in 24 hours (i.e., a rain with the potential to produce erosion and sedimentation), our sampling was dependent on the weather and the contractors. This means that the time between the before, during, and after sampling is highly variable. Since upstream and downstream controls were sampled on the same day as the "at the site" samples, this did not cause a significant analytical problem.

We sampled three sites on each stream, including >100m upstream, at the site, and >100m downstream. We took two replicate Surber samples for macrobenthos, identified to species whenever keys permitted, including chironomids. Chironomids are essential because they often constitute >90% of the individuals sampled, especially in the impacted reaches. The number of samples is small since our objective was not to analyze any one stream in detail, but to treat

streams as replicates. In the overall analyses, multiple samples per site are pseudoreplicates. The mean of the replicate Surber samples was used in the analyses. We electroshocked for fish along one 50m reach of riffles and pools. We collected basic water chemistry data. Water quality parameters included D.O., turbidity, conductivity, Total N, NH_4^+, NO_3^-, Total PO_4^{-3}, SRP, pH, and temperature. We also studied leaf litter decomposition rates. Five g leafpacks of *Cornus florida* (dogwood) leaves were incubated for two weeks *in* situ at all three sites in the "during construction" period to assess the critical ecosystem process of litter decomposition.

Environmental Policy Analysis

Surveys and semi-structured interviews were used to investigate both the regulatory agencies and developers. The surveys focused on the capacityof the agency, the external commitmentthat the agency receives, as well as the internal commitment toward the environment, and the *control* measures that are used. The surveys and interviews achieved a 100% response and participation rate. Although it has been harder to get their cooperation, we have nearly completed data collection from developers. The survey data is being augmented with documentary data from the sediment and erosion control offices in each of the counties.

The evaluation of implementation focused on (1) the extent to which developers comply with sediment and erosion control regulations and (2) the way that regulatory and organizational factors interact to shape compliance behaviors. The examination of outcomes combines social science and biological data to examine associations among regulatory styles, agency activities, and stringency of policy enforcement. We further analyzed how variations in sediment and erosion control enforcement are related to the ecological outcomes (including biological, chemical, and physical factors) in the impacted streams.

Hypotheses

Hypothesis 1. Greatest degradation will be evidenced at the construction sites, compared to upstream controls, with moderate to complete recovery downstream.

Hypothesis 2. Tighter enforcement of erosion and sediment control laws will result in less damage to streams.

Hypothesis 3. Stronger erosion and sediment control regulations will result in less damage to streams.

Results

Nearly all biotic and environmental variables measured tell the same story. Figure 1 shows the changes in the EPT Index for the during construction sampling. That is the species richness of the Ephemeroptera (the mayflies), Plecoptera (the stoneflies), and Trichoptera (the caddisflies). The tally of EPT taxa (i.e., EPT Richness or the EPT Index) is a well-established and universally accepted measure of stream health. These groups of aquatic insects are particularly sensitive to (and highly intolerant of) high temperature, low oxygen, toxic substances, a wide range of pollutants, and burial by sedimentation. An abundance of EPT species and individuals and high EPT diversity are clear indicators of good stream health. Reductions in EPT values demonstrate degradation of stream conditions.

EPT richness follows a pattern. The differences between jurisdictions are clear. The greatest decline in EPT values from upstream to at-the-site occurs in District IV. The EPT Index in Orange County changes little at any site. Wake County actually shows some enhancement of the EPT richness as you go from upstream to at-the-site. We sampled many other variables but the results parallel the EPT richness.

A short summary of the enforcement activities and attitudes of the regulators in the various jurisdictions is found in Table 2. These data show that these agencies differ in these aspects. Orange County had the strictest enforcement, penalizing nearly 25% of all construction projects, while Wake penalized -22% and District IV penalized only ~ 4.5% of the projects they inspected. Orange County is most likely to use stop-work orders to halt construction due to sedimentation violations, while District IV relies on fines. District IV is perceived as being so understaffed that it is unable to make sufficient inspections. Consequently, some contractors do not feel obliged to follow their approved plans. Some

contractors agree to a plan and then cut costs by not following the sediment controls. This laxity is detectable from the stream data (see Figure 1).

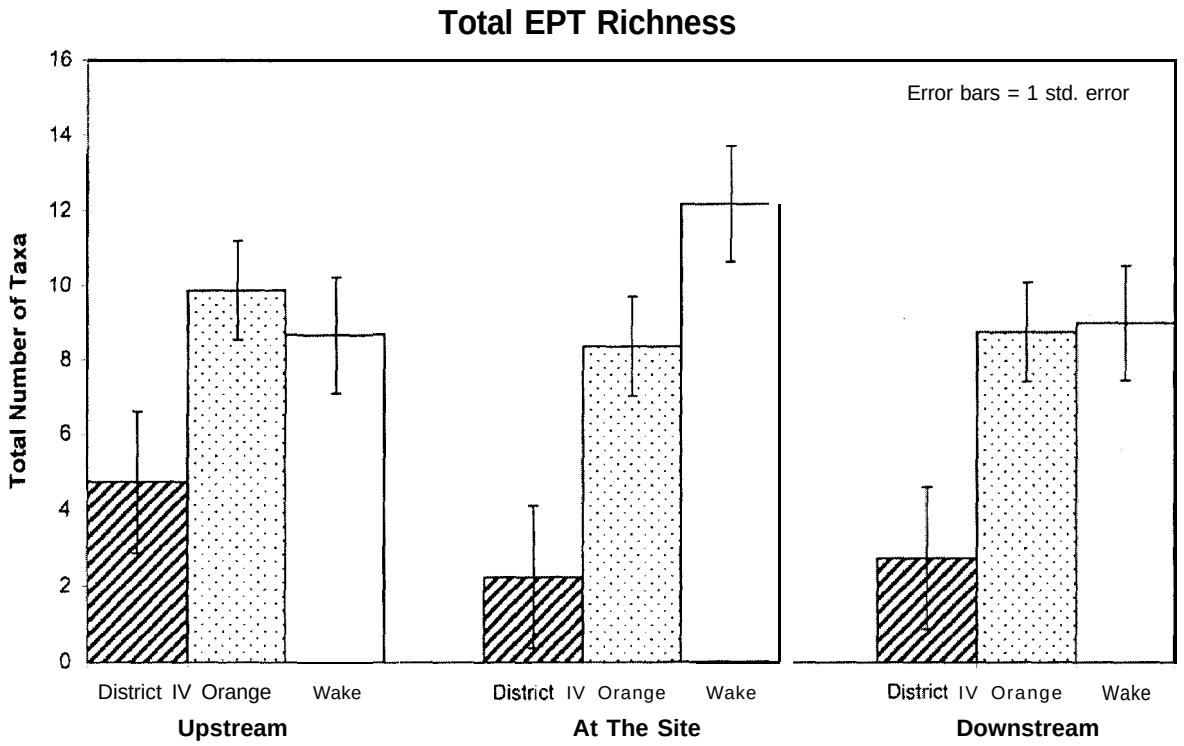

Figure 1. Total EPT Richness.

Table 2. Regulatory Environment

Agency/Variables	Orange County	NC District IV	Wake County
Enforcement Action	Very Strict	Average	Strict
Penalties enacted past year	24	44	88
Stringency of Penalties	High	Medium	Medium
Attitudes of Regulators			
Perception of official commitment	Supportive	Very Supportive	Indifferent
Percent of developers that regulators	8	40	10

Orange County and Wake County regulators generally think that developers will try to avoid complying with erosion and sediment control regulations. As the regulators' workload increases, their task becomes more difficult. This may result in regulators adopting a more forgiving attitude toward developers and less vigorous enforcement of the regulations. District IV regulators think that fully 40% of developers are trying to comply with the regulations.

Discussion

There is a clear link between the attitudes and enforcement activities of the regulators of erosion and sediment control ordinances and environmental outcomes in the streams near construction sites. If the regulations are completely effective, all sites should be similar to the upstream controls when the construction is completed and the site has been

stabilized (i.e., revegetated). In our analysis, the degradation is clearly detectable in the benthic community data (see Figure 1). Benthic communities at the site are dramatically negatively impacted in District IV, unchanged in Orange County, and actually enhanced in Wake County. The effect is sometimes reduced downstream but the degradation persists downstream in District IV.

Wake County and District IV have identical regulations, while Orange County's regulations are more stringent. Comparison between the two jurisdictions with the same rules but different inspection and enforcement intensities will help us tease apart these factors. The stream data suggest that the laws, as written, are not particularly important. Wake County has the best environmental results while District IV has the worst stream degradation. Our analysis suggests that differences in laws and regulations have limited impact on the degree of degradation of stream biota.

The key factors seem to be the attitudes and enforcement behavior of the regulatory agencies. The frequency of on-site inspections is particularly important. In Orange County, every construction site is inspected every week. If it is a problem site, the inspectors may visit daily. In Wake County, the inspections are closer to every other week. In District IV, the goal is to visit every site once in the entire duration of the project. They also seek to respond to any citizen complaints within one week. In Orange County a complaint generates an inspection within one day. Another critical factor is topography. A very steep, erodible slope can undermine the best attempts at enforcement of erosion and sediment control regulations.

Our analysis suggests that differences in the nature and frequency of enforcement and inspections does matter. Developers tell us that a rigid, command and control approach to enforcement is less palatable to them than a flexible problem-solving cooperative approach. If the developers perceive that the regulators are really tying to help them keep sediment on site and out of the streams, they do a better job. Flexibility enters in as follows. If the sedimentation inspectors have enough time to analyze a sedimentation problem in detail, their suggestions will be better. Very often, the inspectors need the authority to implement solutions which are not exactly "by the book." When inspectors propose innovative solutions, which can really solve the problem, this encourages the developers to be more cooperative. More frequent inspections and a cooperative, flexible approach by regulators does ameliorate the stream damage among similar streams in different jurisdictions.

On the other hand, if the developers know that the regulators will in fact shut them down (with a stop-work order or a court injunction), it is easier for the regulators to get developers' attention. Fines are notoriously ineffective penalties in North Carolina. Presently the maximum fine is $500 per day. When developers are pouring millions of dollars into a project, this amount of fine is trivial. As one said, "It's just a cost of doing business." In essence, the effectiveness of erosion and sediment control depends more on enforcement than on how the regulations are written. Even with weak laws, the success of Wake County's Erosion and Sedimentation Control Program plainly depends on their on-site enforcement actions.

Recommendations

. Provide sufficient inspectors to visit each construction site at least weekly.

- Give inspectors the authority and knowledge to implement innovative solutions to erosion problems on a site-specific basis.
- Empower the inspectors to issue severe penalties (stop-work orders) in the case of sedimentation violations.
- Raise the maximum level of fines to a meaningful amount (we suggest $10,000 per day).
- Educate the development community to the damage that sedimentation does to stream communities.